Sharing Potential and the Potential for Sharing: Open Source Licensing as a Legal and Economic Modality for the Dissemination of Renewable Energy Technology

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With only minor deviation, the international community brings together world leaders, diplomats, scholars, corporate enterprises, and nongovernmental organizations roughly every five years to address the most pressing threats to humanity and the environment. Coincidentally, Moore's Law, named after the famous Intel engineer Gordon Moore, posits that technological innovations succeed in quadrupling the number of transistors per circuit—and hence technological and computing capacity—roughly every five years. In every half-decade interval, beginning with the Stockholm Conference in 1972 and following the last summit in Marrakech in 2003, the international community has sought to utilize technology to reduce the seemingly inexorable gap between human progress and environmental degradation.

As reports emerge forecasting the rapid increase in petroleum prices, and as developing parts of the world struggle to secure adequate energy sources for burgeoning economic production, ever-greater attention is being paid to sustainable and renewable forms of energy. Incontrovertible evidence suggests that developing countries are quickly surpassing developed countries in terms of energy demand for their industrial, residential, and commercial sectors.[1] The current and future energy demands of the regions with approximately three-fifths of the world's population are hard to overlook. In order to quench the growing energy needs in the developing world without the accompaniment of traditionally violent and disruptive geopolitical influences, it will be necessary to develop and promote sustainable and renewable forms of energy technology.[2] Presently, many such technologies exist, but have only limited application and are protected by highly coveted, tightly policed proprietary licenses. Proprietary licensing schemes are preventing developing countries from taking advantage of the renewable energy technology that is vital in order for them to meet their accelerating energy demands in a sustainable manner.

There are considerable barriers to the development, deployment, and marketability of renewable energy technologies largely because proprietary licensing schemes only enable use of renewable energy technology in regions where capital is most aggregated and profit margins are abundant. Start-up costs continue to deter new entrants from trying their hand at developing efficient renewable energy systems.[3] Proprietary licenses impose steep costs to firms seeking to purchase protected technology for regional deployment in developing countries. Lastly, proprietary licensing schemes provide an artificial and non-competitive monopoly on technology that has widespread

1. Alex Kirby, *Energy: Meeting Soaring Demand*, BBC NEWS, Nov. 9, 2004, http://news.bbc.co.uk/go/pr/fr/-/2/hi/science/nature/3995135.stm.

2. *See, e.g.*, Tony Cheng, *China Looks to Renewable Power*, BBC NEWS, Mar. 1, 2005, http://news.bbc.co.uk/1/hi/world/asia-pacific/4306997.stm. China's legislature, for instance, has passed a law seeking to increase the use of solar and wind energy to ten percent of China's total energy consumption. *Id.* This move is largely a response to rising oil prices and concerns over environmental degradation. *Id.* China may be one of the fastest growing economies in the developing world and it currently relies on coal for most of its power needs, mining roughly 1.8 billion tons in 2004 alone. *Id.*

3. *See infra* notes 17-20 and accompanying text.

applicability and potentially unimaginable economic and environmental value to developing countries.

Meanwhile, so-called "copyleftists" in the software industry have spawned a movement to create and freely license software programs and operating systems to programmers who promise to then license for free any innovations or improvements. This movement, coined "open source," is gaining momentum and visibility on account of the widespread use of its non-proprietary operating system Linux and because of the allure of freely disseminated software. This article suggests that this open source modality, increasingly popular in the software industry, ought to supplant proprietary systems in other areas. Specifically, the non-proprietary licensing espoused by open source developers provides a unique economic and legal modality for development and dissemination of renewable energy technology.

Part I of this article will discuss various multilateral treaties that address renewable energy development. In particular, this article will explore the legal and normative support for collaborative transfer of renewable energy technology. Part II of this article will trace a brief history of the open source movement and introduce some basic tenets of its philosophy. In doing so, Part II will draw from theory on sharing and collaborating as an economic modality.[4] A basic economic and legal analysis of open source will follow. Part III will synthesize the open source philosophy with the practical legal and economic hurdles interposed by existing technology frameworks. Lastly, this article will argue that non-proprietary licensing of renewable energy technology would promote more regional and national renewable energy economies of scale, effectively divert the use of unsustainable and non-environmentally friendly energy sources, and equitably and efficiently disseminate renewable energy technology, thus maximizing its utility.

I. MULTILATERAL FRAMEWORK FOR RENEWABLE ENERGY TECHNOLOGY

This section will survey the landscape of multilateral treaties pertaining to renewable energy dissemination and development. The various sources of renewable energy-related treaties herein discussed provide authority for the proposition that the law ought to encourage the use of an open source modality for renewable energy dissemination to developing countries.

International law pertaining to renewable energy technology, though highly politicized by interest groups and national political agendas, remains largely a creature of aspirational multilateral declarations. National governments are loath to commit to positions that an administration believes may hinder future economic development. Notwithstanding the politicization of global environmen-

4. *See generally* Yochai Benkler, *Sharing Nicely: On Shareable Goods and the Emergence of Sharing as a Modality of Economic Production*, 114 YALE L.J. 273 (2004).

tal issues as partisan fodder, multilateral and institutional attempts to address core environmental values have focused on renewable energy as the centerpiece of a sustainable political solution. Presently, the limited application and availability of renewable energy technology demonstrates the limitations of proprietary systems of technology dissemination, which play a role in hindering widespread deployment of "environmentally safe" energy. A significant body of institutional declarations and international partnerships reveals the emergence of a growing consensus on the need to freely disseminate renewable energy technology. Although few of the foregoing instruments create binding legal obligations on participating states, the textual references to renewable energy technology dissemination and technology sharing supports the legal recognition of non-proprietary technology licenses as a mechanism to develop, distribute, and deploy technology. Thus, international legal support exists for the enshrinement of the open source modality for renewable energy dissemination.

This part will analyze language in various international institutions' declarations and agendas that provides safe harbors and legal protection for non-proprietary licensing mechanisms for renewable energy technology. The various multilateral treaties herein discussed represent a non-exhaustive survey of landmark international environmental instruments that provide a context for the enshrinement of the open and free dissemination of renewable energy technology.

A. RIO DECLARATION

The Rio Declaration demonstrates that open source principles underlie the current state of international environmental law. In June 1992, the United Nations General Assembly met on the environment and development with the goal of "establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people."[5] The General Assembly concluded the conference by issuing the Rio Declaration on Environment and Development (Rio Declaration), which reaffirmed the Stockholm Declaration and sought to promote international environmental and developmental agreements.[6] The resultant Rio Declaration proclaimed a panoply of principles that the drafters may not have expected to immediately become binding international law, but undoubtedly hoped states would pursue through diplomatic and legal avenues.

The foregoing discussion introduces and outlines the essential character of the principles proclaimed in the Rio Declaration. Of all of the principles, the following relate directly to the notion that states ought to promote the use of

5. United Nations Conference on Environment and Development, Rio Declaration on Environment and Development, June 14, 1992, U.N. Doc. A/CONF.151/5/Rev.1, *reprinted in* 31 I.L.M. 874.

6. *Id.*

renewable energy technology. Principle 2 recognizes the sovereignty of states to exploit their own resources under national environmental and developmental policy, but also concurrently recognizes the responsibility of states to ensure that domestic activity does not contribute to transnational environmental degradation.[7] Principles 3 through 6 articulate notions of developmental and generational equity, cooperation towards eradicating poverty and development, and special treatment of developing countries.[8] Principle 7, although non-binding, provides that "States *shall cooperate* in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem" and acknowledges the disparate contributions toward environmental degradation between developed and developing countries.[9] The term "shall cooperate" is more than a term of art; it suggests that states have an affirmative duty to cooperate. Cooperation, although broad in meaning and ill-defined in the Rio Declaration, suggests that states ought to promote inclusive and collaborative means of achieving the common goals outlined in the preamble.

Principle 9 provides some clarification to the definition of "cooperation" in the Rio Declaration. Principle 9 encourages states to "strengthen endogenous capacity-building for sustainable development" and lists numerous methods, such as: "improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies."[10] Throughout the Rio Declaration, the drafters quite clearly contemplated that substantial barriers to technological development and diffusion existed, and thus they sought to indoctrinate a notion of technology sharing through a new paradigm. This prescription—that states should promote technology sharing—lends credibility to the proposition that open source modality could effectively catalyze the technology development contemplated in the Rio Declaration.

B. UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The United Nations Convention on Climate Change brought together leagues of interested states to construct and agree upon a systematic and institutionalized approach to climate change. The participating states grouped themselves into Annexes (I and II) with different obligations pertaining thereto and sought input

7. *Id.* princ. 2.

8. *Id.* princs. 3-6.

9. *Id.* princ. 7 (emphasis added). It is important to note that Principle 7 is non-binding because states remain free to decide whether to implement the principle's essential mandate. On the other hand, the principle's use of the term "shall" connotes a sense of obligation, albeit not by any legislative or judicial process. Further, because the Rio Declaration is a non-binding source of international law, it leaves the method of implementation to the discretion of state actors. Therefore, it is feasible to implement an open source modality for renewable energy dissemination that is consistent with, and encouraged by, the current state of the law.

10. *Id.* princ. 9.

from experts to provide analytical support to the ongoing negotiations and discussions. At the beginning of the new millennium, the Annex I Expert Group on the United Nations Framework Convention on Climate Change (UNFCCC) requested a report on international energy technology and climate change from the Organization for Economic Cooperation and Development (OECD) and the International Energy Agency (IEA).[11] The OECD and the IEA surveyed numerous international agreements to divine the current international legal landscape relating to international technology transfer and environmental pollution.[12] The two organizations assessed the capacity of various international organizations to deliver financing to green technology initiatives and proposed four basic prescriptions for promoting environmentally-friendly technology transfer.[13] The jointly submitted report, entitled International Energy Technology Collaboration and Climate Change Mitigation (IETCCCM), postulated that "international technology cooperation, by sharing information, costs, and efforts, might accelerate and facilitate technical change towards more climate-friendly technologies."[14] Although not binding on the Annex I Expert Group or the UNFCCC, the report provides persuasive support for a technology-sharing paradigm to alleviate climate change. Notably, the IETCCCM uses a narrow definition of technology transfer throughout its report: "technology transfers flowing from Annex II countries to non-Annex I countries."[15]

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11. OECD Env't Directorate, Int'l Energy Agency, *International Energy Technology Collaboration and Climate Change Mitigation*, OECD/IEA Doc. COM/ENV/EPOC/IEA/SLT(2004)1 (2004) (*prepared by* Cédrick Philibert) [hereinafter *IETCCCM*]. "The Annex I Expert Group oversees development of analytical papers to provide useful and timely input to the climate change negotiations." *Id.* at 3. The Annex I Parties to the UNFCCC include: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, the European Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, and the United States of America. *See* United Nations Framework Convention on Climate Change art. 4.1(c), May 9, 1992, 1771 U.N.T.S. 107, 31 I.L.M. 849 (entered into force Mar. 21, 1994) [hereinafter UNFCCC].

12. *See IETCCCM*, *supra* note 11, at 6.

13. *See id.* at 7. The report suggests, first, that it is crucial to "further strengthen and 'green' international trade and investment." *Id.* Second, it is important "to seek new and strengthen existing agreements in ways to share the 'learning investments' necessary to bring new climate-friendly technologies into the marketplace." *Id.* Third, "better coordination between governments" with respect to testing methods, consumer information, performance standards and promotional labeling would be helpful. *Id.* Lastly, the report suggests increasing "the possibilities of flexible mechanisms in fostering technology transfer" to greatly enhance a "move from project-based approaches to international emissions trading" systems in both industrialized and developing countries. *Id.*

14. *Id.* at 6. The report attempted to quell the fears of free-market enthusiasts by suggesting that cooperation between states "should not preclude competition between companies" and opined that cooperation might catalyze "governments to increase their efforts" to support basic research and development. *Id.*

15. *Id.* at 8. The report noted, however, that the Intergovernmental Panel on Climate Change (IPCC) broadly defines technology transfer as:

> a broad set of processes covering the flows of know-how, experience, and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector

The IETCCCM provides strong support for the technical and economic advantages to a model of technology sharing that relies on collaboration rather than competition. The IETCCCM addresses the economic characteristics of technology sharing and opines that research and development cooperation magnifies results and helps to more quickly disseminate the resultant technology.[16] Specifically, the report cites reduced research and development costs when states collaborate on their energy technology developments because cooperative economic behavior enables result sharing, avoids duplication of efforts, and increases the rate of technological innovation.[17]

The IETCCCM applies a comprehensive economic assessment of technology sharing and concludes that because environmentally-friendly technologies are akin to public goods, free markets provide imperfect incentives towards innovation and thus supply is insufficient for the market.[18] The report notes that the enormity of energy technology's start-up costs discourages many countries from developing the technology on their own.[19] For example, the report cites a four-country nuclear fusion initiative that initiated one of the largest international cooperation projects in the technology realm.[20]

While the authors of the IETCCM have their greatest expertise in economic development, they thought it wise to include relevant provisions of the UNFCCC in their report to bolster the international legal credibility of the report's findings and conclusions. Contrary to the Rio Declaration, which was primarily aspirational, the UNFCCC has many signatory states and creates binding treaty obligations.[21] Consequently, the UNFCCC is an even stronger normative statement in support of a collaborative model of technology dissemination. Several specific provisions are noteworthy. For example, the UNFCCC provides in Article 4.1(c) that all parties "shall *promote and cooperate* in the development, application and diffusion, including transfer, of technologies . . . in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors."[22] Further, Article 4.2(e) provides that Annex I parties "shall coordinate as appropriate with other such Parties, relevant economic and administrative instruments developed to achieve the objective of the Conven-

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> institutions . . . . The broad and inclusive term "transfer" encompasses diffusion of technologies and technology cooperation across and within countries. It covers technology transfer processes between developed countries, developing countries and countries with economies in transition, amongst developed countries, amongst developing countries and amongst countries with economies in transition.

Id. For purposes of this article, technology transfer will refer to the definition provided by the IPCC. *Id.*

16. *See id.* at 10.
17. *See id.*
18. *See id.*
19. *See id.*
20. *See id.* This project was called the International Thermonuclear Experimental Reactor (ITER). *Id.*
21. *See infra* Part III.B.
22. *See* UNFCCC, *supra* note 11, art. 4.1(c) (emphasis added).

tion."[23] Article 4.5 contains language that is remarkably similar to the Rio Declaration, stipulating: "The developed country Parties and other developed Parties included in Annex II *shall take all practicable steps to promote, facilitate and finance, as appropriate*, the transfer of, or access to, environmentally sound technologies and know-how to other Parties . . . ."[24]

The UNFCCC created a Conference of the Parties (COP) to facilitate and implement the goals of the Convention.[25] Notably, the seventh annual COP in Marrakech established an Expert Group on Technology Transfer (EGTT) to effectuate implementation of Article 4.5 of the UNFCCC.[26] The COP agreed on a technology framework including four basic activities: technology needs assessments, technology information, enabling environments for technology transfers, and capacity building.[27] An international undertaking developed organically from the UNFCCC as the COP to provide services, create an electronic technology clearinghouse, hold technology workshops, facilitate macroeconomic policy reforms, and create legal and regulatory frameworks to promote transnational technology transfer.[28]

C. AGENDA 21

At the Rio Conference in 1992, more than 178 states adopted a comprehensive plan of action to address anthropogenic impacts on the environment.[29] The Rio Conference produced Agenda 21, which was intended to showcase and codify an international consensus on a framework for global cooperation on environmental and developmental issues.[30] The magnitude and far-reaching vision of Agenda 21's scope is apparent from its four broadly entitled sections that relate to technology, humanity, and the environment.[31]

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23. *See id.* art. 4.2(e).

24. *See id.* art. 4.5 (emphasis added). "In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties." *Id.*

25. *See id.* art. 7. The Kyoto Protocol, among other treaties, is the product of negotiations between and among the Conference of the Parties (COP).

26. *See IETCCCM*, *supra* note 11, at 19.

27. *See id.*

28. *See id.* at 19-20. Financing for climate change projects is available through the Global Environment Facility, which has provided US$1 billion for such projects and leveraged more than US$5 billion in co-financing. *Id.* at 20. More than half of the Global Environment Facility's financing has gone towards renewable energy projects and more than a quarter has been devoted to energy efficiency projects in forty-seven developing and transitional economies. *Id.* In 2002, the international environmental legal framework again intersected with technological economies of scale when donor nations agreed to replenish the fund by US$3 billion just before the World Summit on Sustainable Development in Johannesburg. *Id.*

29. *See* U.N. Dep't of Econ. & Soc. Affairs, Division for Sustainable Development, http://www.un.org/esa/sustdev/documents/agenda21/index.htm (last visited Nov. 12, 2005).

30. *Report of the United Nations Conference on Environment and Development, Agenda 21*, U.N. GAOR, 47th Sess., U.N. Doc. A/CONF.151/26 (1992), *available at* http://www.un.org/esa/sustdev/documents/agenda21/english/Agenda21.pdf [hereinafter *Agenda 21*].

31. *See id.* §§ I-IV. The sections are entitled as follows: Social and Economic Dimensions; Conservation and

Agenda 21 acknowledges that international economics is a key component of any strategy to address developmental and environmental issues.[32] Therefore, Agenda 21 targets international trade as the primary vehicle for effectuating an "open, secure, non-discriminatory and predictable multilateral trading system" that "leads to the optimal distribution of global production in accordance with comparative advantage."[33] Chapter 2 of Agenda 21 discusses the economics of sustainable development in terms of the special and differential status of developing and least developed countries and recognizes the modern day inequities of the international trading system.[34] Chapter 2 also sets out a series of objectives that appear to impose aspirational benchmarks, rather than obligations, on national governments, including: promoting an open and equitable multilateral trading system, improving market access for exports of developing countries, improving functioning of commodity markets, and promoting and supporting both domestic and international policies that align economic growth and environmental protection.[35]

Of primary importance to the realm of energy technology is Agenda 21's chapter on "Transfer of Environmentally Sound Technology, Cooperation and Capacity-Building," which views technology holistically, considering all inputs, processing, and products of a particular technology.[36] In line with a holistic understanding of technology, Chapter 34 of Agenda 21 addresses total technology systems, including knowledge management procedures, goods and services, equipment, and organizational and managerial procedures.[37] To facilitate the

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Management of Resources for Development; Strengthening the Role of Major Groups; and Means of Implementation. *Id.* For purposes of this article, Section IV is the most critical because it establishes a framework in which to address anthropogenic causes of environmental degradation.

32. *See id.* ch. 2. "Economic policies of individual countries and international economic relations both have great relevance to sustainable development. The reactivation and acceleration of development requires both a dynamic and a supportive international economic environment and determined policies at the national level. It will be frustrated in the absence of either of these requirements. A supportive external economic environment is crucial." *Id.* ch. 2.2.

33. *See id.* ch. 2.5.

34. *See id.* chs. 2.5-2.8; *see also* Jason Wiener, World Trade Organization's Identity Crisis: Institutional Legitimacy and Growth Potential in the Developing World (Dec. 21, 2004) (unpublished manuscript, on file with the author).

35. *See Agenda 21*, *supra* note 30, ch. 2.9. Chapter 33's "Financial Resources and Mechanisms" provisions are central to efforts that promote economic growth, social development and poverty eradication, but are only tangential to the scope of this article. *Id.* ch. 33. Chapter 33 rests on General Assembly Resolution 44/228, which essentially charged the U.N. Conference on Environment and Development with identifying and providing new financing mechanisms for environmentally sound research, projects and other developmental initiatives. *Id.* Under the "Means of Implementation" section, financing in developed countries is left to the public and private sectors, and developing countries must rely on international aid transfers from developed countries, which must meet a target percentage of national gross national product. *Id.* ch. 33.13.

36. *See id.* ch. 34. Chapter 34.1 provides: "Environmentally sound technologies protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes." *Id.* ch. 34.1.

37. *See id.* ch. 34.3. Chapter 34 is based on the notion that technology ought to serve the essential needs of

spread of environmentally friendly technology, Chapter 34 acknowledges that:

> There is a need for favourable access to and transfer of environmentally sound technologies, in particular to developing countries, through supportive measures that promote technology cooperation and that should enable transfer of necessary technological know-how as well as building up of economic, technical, and managerial capabilities for the efficient use and further development of transferred technology. Technology cooperation involves joint efforts by enterprises and Governments, both suppliers of technology and its recipients. Therefore, such cooperation entails an iterative process involving government, the private sector, and research and development facilities to ensure the best possible results from transfer of technology.[38]

Chapter 34's holistic understanding of increasing access to and transfer of technology is particularly important in developing countries to promote sustainable development, sustain the world's economy, protect the environment, and alleviate poverty and human suffering.[39]

Chapter 34 acknowledges the legal and practical limitations of proprietary technology systems and supports a cooperative model of technology sharing to disseminate renewable energy technology to developing countries. Chapter 34 notes that a substantial body of technological knowledge lies in the public domain and that access to such knowledge in the developing world is crucial.[40] Further, this chapter considers the role of patent protection and intellectual property rights that adhere to environmentally sound technology, while also encouraging exploration of ways to ensure access for developing countries to such technology.[41] Chapter 34.11 explicitly addresses the availability of proprietary technology through commercial channels and recognizes its import for technology transfer.[42] A recapitulation of this chapter's objectives can be found in 31.14. The objectives set out in Chapter 34 resemble the principles set forth in the Rio Declaration and the UNFCCC, all of which stress the importance of a collaborative model of technology development.[43] In Chapter 34's "Activities" section, governments are urged to encourage the private sector to promote

humans and that regional differences in human resource development, capacity-building, gender, socio-economic conditions cultural and environmental priorities should be relevant to technology transfer. *Id.*

38. *See id.* ch. 34.4.

39. *See id.* ch. 34.5. According to Chapter 34, the primary goal of improved access to technology information is "to enable informed choices, leading to access to and transfer of such technologies and the strengthening of countries' own technological capabilities." *Id.* ch. 34.8.

40. *See id.* ch. 34.9.

41. *See id.* ch. 34.10.

42. *See id.* ch. 34.11. This chapter encourages exploiting the pool of proprietary technology and combining it with local innovations to generate alternative technologies. Further, "enhanced access to environmentally sound technologies should be promoted, facilitated, and financed as appropriate, while providing fair incentives to innovators that promote research and development of new environmentally sound technologies." *Id.*

43. *See id.* ch. 34.14.

effective modalities for access to and transfer of technology by: formulating policies for effectively transferring environmentally sound technology that is in the public domain; creating favorable conditions to encourage private and public innovation of said technologies; examining subsidies, tax policies, and regulations to eliminate impediments to the transfer of said technology; and creating a framework for transferring privately owned technologies to developing countries.[44] Chapter 34 conflates proprietary technology and technology residing in the public domain as mere alternative modalities for purposes of technology transfer. It implies that despite their competing philosophical value, both are vehicles for increasing access to technological knowledge and capacity for deployment.[45] While this article argues that a public domain or collaborative model is the better modality, Chapter 34 still provides support for adoption of an open source paradigm of technology dissemination. In summary, Chapter 34 of Agenda 21 weds the vast body of public technology knowledge with the need for a collaborative system of technology sharing and dissemination.

D. INTERNATIONAL PROLIFERATION TREATY FOR RENEWABLE ENERGIES – THE IMPORTANCE OF NONGOVERNMENTAL ORGANIZATIONS

A global nongovernmental organization, named the World Council for Renewable Energy, has drafted a supplementary protocol to the Nuclear Non-Proliferation Treaty (NPT) of 1970.[46] While the International Proliferation Treaty for Renewable Energy (IPTRE) has not been submitted for a formal vote by the contracting parties to the Nuclear Non-Proliferation Treaty, the IPTRE illustrates the important work contributed by NGOs in promoting the use of renewable energy and demonstrates the relatedness of renewable energy to other global issues, such as international nuclear security. In light of the near unanimous global support for the NPT, the IPTRE would have enormous economic and legal implications if it were to be voted on as a supplementary protocol. The IPTRE demonstrates the strength of non-state support for technology sharing as opposed

44. *See id.* ch. 34.18.

45. While beyond the scope of this article, Chapter 39 addresses the need to develop, update, contribute towards, increase participation in, and clarify international legal instruments relating to the environment and relevant social and economic agreements. *See id.* ch. 39.1. Effective frameworks for technology transfer rely on well-developed and revered bodies of international environmental law. This chapter presupposes that the current state of international environmental and development law is ambiguous, disconnected, imbalanced, and underrepresented. To the extent that the multilateral and bilateral treaty system acts as a protector and stabilizer of global environmental and developmental interests, its lack of effective functionality hinders technology transfer to satisfy human needs.

46. WORLD COUNCIL FOR RENEWABLE ENERGY, INTERNATIONAL PROLIFERATION TREATY FOR RENEWABLE ENERGIES (DRAFT FOR A SUPPLEMENTARY PROTOCOL TO THE NUCLEAR NON-PROLIFERATION TREATY OF JULY 1, 1970), http://www.world-council-for-renewable-energy.org/downloads/Verbreitung-engl.pdf [hereinafter IPTRE]. The Nuclear Non-Proliferation Treaty has been signed by 187 states as of 2002 and has been in force since 1970. *See* Treaty on the Non-Proliferation of Nuclear Weapons, *opened for signature* July 1, 1968, 21 U.S.T. 483, 729 U.N.T.S. 161 (entered into force Mar. 5, 1970), *available at* http://www.state.gov/t/np/trty/16281.htm.

to patent systems of technology licensing. If implemented, the IPTRE would be a vehicle for adopting an open source methodology in the realm of technology dissemination.

The Preamble to the IPTRE seeks harmony with the fundamental aims of Agenda 21 and addresses the myriad problems associated with utilizing fossil fuel-based energy technologies.[47] The Preamble acknowledges several related concerns, including, *inter alia*, the destruction of vegetation zones, energy demand posed by growing populations, disproportionality of population and energy consumption, the public good nature of the environment, the inexhaustibility of renewable energies, and the need to offer states opportunities to exchange scientific information and technical developments.[48] Article I would impose obligations on the contracting parties to exchange knowledge of renewable energy technologies and improved energy efficiency.[49] Article III would require the contracting parties to join the International Renewable Energy Agency, which would serve as a clearinghouse for renewable energy technology, approve transfers of technology to improve energy efficiency, and provide relevant services.[50] Article IV discusses development aid for renewable energy and action programs, and Article V addresses international trade in renewable energies.[51] Article VI of the IPTRE would obligate states to determine the actuarial social cost of fossil and nuclear energies and prohibit states from taking discriminatory measures against another state that estimates the social cost of its domestic energy supply.[52]

In summation, several international environmental treaties provide support for the utilization of an open source modality for renewable energy technology dissemination. The Rio Declaration declared fundamental principles that should guide states in developing sustainable forms of energy technology. The UNFCCC added an institutional skeleton to the Rio Declaration's broad conceptual framework. Agenda 21 began the pragmatic implementation phase of the international movement towards promoting dissemination of renewable energy technology by an open source methodology. The IPTRE added an external layer of interest from nongovernmental organizations. Taken together, this international environmental paradigm sets forth a philosophical and operational framework for utilizing an open source modality for effectively disseminating renewable energy technology

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47. *See* IPTRE, *supra* note 46, pmbl.

48. *See id.*

49. *See id.* art. I.

50. *See id.* art. III. The International Renewable Energy Agency does not currently exist. However, the International Energy Agency addresses renewable energy issues. *See* IEA Energy Information Centre, Renewable Energy, http://www.iea.org/Textbase/subjectqueries/keyresult.asp?KEYWORD_ID=4116 (last visited Nov. 12, 2005).

51. *See* IPTRE, *supra* note 46, arts. IV-V. The idea that international trade is related to renewable energy dissemination resembles a central tenet of Agenda 21. *See Agenda 21*, *supra* note 30 and accompanying text.

52. *See* IPTRE, *supra* note 46, art. VI.

to developing countries.

II. THE OPEN SOURCE MOVEMENT IN SOFTWARE PRODUCTION

Since the advent of the personal computer nearly twenty-five years ago, two competing philosophical systems have battled for domination of what has become one of the most ubiquitous industries affecting every realm of society and humanity.[53] From these two schools of thought emerged contrasting legal regimes designed to protect the monopoly rights of authors on the one hand and to ensure free public access on the other. Proprietary software conventionally involves payment for a single-use license to an individual end-user. These licenses typically rely on the full copyright protection afforded by law and prohibit unauthorized reproduction or modification. Independent programmers who wish to make improvements must obtain highly coveted authorization to develop derivative software.[54] The software's "KERNEL", or core code, is generally retained in secret by the software's owners. In certain limited instances, commercial software developers authorize third-party developers to use layers—isolated kernels of code—of the proprietary software to promote compatibility with a wide range of software.[55] In the proprietary form, commercial software enterprises rely on the existence and enforcement of copyright law and competitively negotiated license agreements to capitalize on a given code package.[56]

Open source philosophy, on the other hand, began with the notion that source code should be "released without authorial restrictions on copying or derivation—a notion that could be accomplished by simply releasing one's work into the public domain" and evolved "into software governed by a licensing scheme that would prohibit authors of derivations from placing restrictions on the distribution of their derived works that had not been placed on the distribution of the original code."[57] These competing models fundamentally differ in the level to which they concentrate property rights in the original author.

A. OPEN SOURCE VS. PROPRIETARY: THE HISTORY OF TWO COMPETING MODELS

To prevent the "proprietization" of derivative software, Richard Stallman, the father of the modern day open source movement, created the General Public License (GPL), a legal form now used to license a myriad of free software.[58]

53. *See* Jonathan Zittrain, *Normative Principles for Evaluating Free and Proprietary Software*, 71 U. CHI. L. REV. 265, 265 (2004).

54. *Id.*

55. For example, Microsoft would enter into a license agreement with a third-party software company, such as Symantec, to enable programmers to write anti-virus software that can facilely inhabit the Microsoft Windows operating system environment.

56. *See* Zittrain, *supra* note 53, at 266, 269.

57. *Id.* at 268-69.

58. *See id.* Richard Stallman is credited with authoring GNU/Linux, which is a non-proprietary and widely

GPLs, and similar licenses, prevent authors of derivative software from imposing more restrictive copyrights on free software by using the copyright convention to attach binding covenants to the non-proprietary code.[59] Other types of non-proprietary licenses impose no such "copyleft" restrictions, and may only require derivative software developers to give attribution or credit to the original author.[60] Both "open" and "free" source licenses essentially seek to maintain public access to source code and to prevent developers from appropriating or privatizing the copyright of source code. Stallman believed that open source would become a social movement predicated on the notion that non-rivalrous goods should be free as a matter of ethics.[61] Today, open source firms are sprouting up due to robust investment by venture capital firms that believe in the success of the open source methodology.[62]

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used operating system that rivals the Microsoft Windows operating system. *Id.* The General Public License (GPL) spawned a variety of non-proprietary licenses, but all contain certain basic elements, including:

1. No royalty or other fee imposed upon redistribution.
2. Availability of the source code.
3. Right to create modifications and derivative works.
4. May require modified versions to be distributed as the original version plus patches.
5. No discrimination against persons or groups.
6. No discrimination against fields of endeavour.
7. All rights granted must flow through to/with redistributed versions.
8. The license applies to the program as a whole and each of its components.
9. The license must not restrict other software, thus permitting the distribution of open source and closed source software together.

Mark Webbink, *Understanding Open Source Software*, GROKLAW, Dec. 31, 2003, http://www.groklaw.net/article.php?story=20031231092027900.

59. *See* Zittrain, *supra* note 53, at 269. Open Source licenses can be classified into two categories. One type applies no restrictions on the distribution of derivative works (i.e., non-protective), and the second type applies restrictions that ensure that the code will always remain free and/or open. *See* Webbink, *supra* note 58.

60. *See* Zittrain, *supra* note 53, at 269; Webbink, *supra* note 58; Severine Dusollier, *Open Source and Copyright: Authorship Reconsidered?*, 26 COLUM. J.L. & ARTS 281 (2003); Christian Nadan, *Open Source Licensing: Virus or Virtue?*, 10 TEX. INTELL. PROP. L.J. 349 (2002). For purposes of this article, both "open" and "free" source software will be referred to generally to contrast with proprietary software licenses, which reserve all rights to the author except a license to use the software on the licensee's computer.

61. *See* Zittrain, *supra* note 53, at 274. Perhaps unintended, the open source philosophy is supplying alternative economic, political, and legal structures for activists and social movements. *See* Jeffrey S. Juris, *The New Digital Media and Activist Networking Within Anti-Corporate Globalization Movements*, 597 ANNALS AM. ACAD. POL. & SOC. SCI. 189, 191-92 (2005). Based on writings of social scientist Steven Weber, "open source could potentially revolutionize production within other information-based sectors, such as primary care medicine or genomics." *Id.* at 192. "The horizontal networking logic facilitated by new digital technologies not only provides an effective method of social movement organizing, it also represents a broader model for creating alternative forms of social, political, and economic organization." *Id.*

62. *See* Gary Rivlin, *Open Wallets for Open-Source Software*, N.Y. TIMES, Apr. 27, 2005, at C1. Despite early difficulties, the open source software movement has gained considerable trust among venture capitalists following the large-scale success of Red Hat, which charges for support services, but develops source code under the open source license. *Id.*

B. WHY OPEN SOURCE WORKS WITH SOFTWARE: INCENTIVES AND ECONOMICS

There are three specific characteristics of software that make it amenable to open source distribution. First, the software industry is comprised of participants who respond to non-economic incentives, thereby minimizing the problem of free riders. Second, the economics of the open source movement have revolutionized software development in the unique way open source theory emphasizes non-monetary forms of compensation and the factors that motivate production. Third, software is a non-depletable good that can be easily and inexpensively shared.

1. How Open Source Overcomes Free Riders

The open source movement bases its philosophy on notions of reciprocity and collective action. Traditional economic theory suggests that the public good represents a contribution vacuum in which the well-known "free rider" effect discourages any action by individuals unless individual actors are motivated by external incentives to contribute their labor.[63] Reciprocity theory suggests conversely that "[i]ndividuals who have faith in the willingness of others to contribute their fair share will voluntarily respond in kind."[64] Thus, one instance of cooperation breeds further and sustainable cooperation because individuals observe others contributing to the public good and therefore reciprocate based on the faith that contribution will become cyclically forthcoming.[65]

In the context of intellectual property and technology, Professor Kahan suggests that academia is a prime example of the possibility of a reciprocal alternative to proprietary production.[66] Kahan contends that scholars are not motivated to reciprocate in the production and exchange of ideas merely by probable financial gain, but instead by hopes for improved status, wider recognition, and the simple satisfaction of participating in shared intellectual projects.[67] Critically, Kahan suggests that enterprises have already successfully incorporated the academic model into the commercial world by supplying internet portals,and by encouraging employees to attend academic conferences and publish scholarly articles.[68]

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63. *See* Dan M. Kahan, *The Logic of Reciprocity: Trust, Collective Action, and Law*, 102 MICH. L. REV. 71, 72 (2003).

64. *See id.*

65. *See id.*

66. *See id.* at 90 ("Academics freely exchange ideas by teaching, attending conferences, and most importantly by publishing books and articles."). Kahan argues that the exchange of ideas is reciprocal because authors build on published work of their predecessors and because authors credit prior work with citations. *Id.*

67. *See id.* at 91.

68. *See id.* at 92. Information-intensive industries prefer that their researchers openly disseminate their ideas in order to attract the most talented researchers. *Id.* at 93.

2. The Economics of Open Source

Open source programming is sustained by the same individual motivations that propel reciprocal intellectual production in universities.[69] The widespread popularity and the ever-expanding application of open source software substantiates the "reciprocity social theory" and suggests that open source code producers value peer recognition, status, and the positive reputation accorded to valuable contributions.[70] In economic parlance, open source producers generate at least some utility from participating in reciprocal intellectual production systems, and thus, they can rely less on intellectual property rights to reward creativity and quality. In sum, Professor Kahan argues that reciprocal systems of collective action have broad and effective economic and legal applications.[71]

Traditional macroeconomic theory suggests that where inadequate supply-side incentives exist, insufficient revenue or profit potential will discourage firms from entering a market to recapture initial investment. This can be especially true in the case of capital-intensive technologies where significant financial barriers to entry exist and where start-up costs are amortized over long periods of time. Open source industries, however, rely on demand-side incentives to drive competitiveness.[72] Ultimately, consumers' market choices will drive an industry that produces under different and competing theories of production. Further, since open source is a diffuse system of ad hoc software production, demand will also efficiently lead to product innovations because programmers will seek to deliver software updates and new code that address the current needs of consumers.[73] The open source method of producing software helps to defray the cost of innovation because ad hoc patches and updates can take the place of re-investing in research and development to program a full-fledged update.

Historically, open source technology flourishes in its own right. Even when in

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69. *See id.* at 94.

70. *See id.*

71. *See generally id.* at 72.

72. *See* Ganesh Prasad, *Open Source-onomics: Examining Some Pseudo-economic Arguments About Open Source*, LINUX TODAY, Apr. 12, 2001, *available at* http://linuxtoday.com/news_story.php3?ltsn=2001-04-12-006-20-OP-BZ-CY. Theory suggests that because consumers experience substantial cost savings by using open source software, there is a strong incentive to prefer open source software over proprietary counterparts. *Id.* Open source software has an advantage over proprietary systems in that it can develop "static efficiency" more quickly by pricing products at marginal cost, something proprietary developers cannot do because of the need to maximize profits and recoup costs. *See* Klaus M. Schmidt & Monika Schnitzer, *Public Subsidies for Open Source? Some Economic Policy Issues of the Software Market*, 16 HARV. J.L. & TECH. 473, 477-79 (2003).

73. *See* Prasad, *supra* note 72. In proprietary software development, three external effects may distort incentives for innovation: (1) consumer surplus often stems from an innovating firm's inability to perfectly price discriminate, which causes it to be unable to recapture the entire increase in consumer surplus generated by innovation; (2) firms have difficulty gauging the cross-market applicability of innovations and thus the incentive to innovate does not reflect the full market potential of research and development; and (3) the business-stealing effect, whereby superior technology makes some existing technology less attractive, can increase the cost of research and development or cause an over-investment in research and development. *See* Schmidt & Schnitzer, *supra* note 72, at 480-81.

competition with proprietary modalities, open source has demonstrated its capacity to be a high quality and coveted alternative.[74] Linux has shown a steadily increasing consumer base since its advent in the mid-1990s, and its platform for compatible products is growing as well.[75] Similar to the software industry, proprietary systems often lead to imperfect incentives for innovation due to the enormity of research and development investment. Microsoft has been embroiled over patent and copyright litigation in several countries largely due to its market prowess and because it stands at the apex of the software industry. Under a more diffuse system of technology development, innovation costs would decrease and producers could more readily achieve static and dynamic efficiency.[76]

3. Open Source is an Effective Model for Shareable Goods

Open source is succeeding as a modality for computer hardware production because of the characteristics of the computation framework. Computers are shareable goods because they provide "functionality in discrete packages rather than in a smooth flow," and one must purchase some "threshold computation capacity" that delivers at least a minimum amount of computation regardless of how much of that computation capacity is needed.[77] Another characteristic of shareable goods is the existence of excess capacity which can be utilized in secondary markets, shared or managed—a notion Professor Benkler calls "granularity."[78] Sharing of such excess capacity involves relatively low transaction costs, improves the information on which "granular" resources act, and provides better motivation for exploiting excess capacity.[79] Benkler's shareability model supplies an attractive alternative to traditional market-based and institutional approaches to resources with certain characteristics, including parallel processing, ease and cost of utilizing excess capacity, rapidity of resource's decay, and existence of secondary markets for overcapacity.[80]

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74. *See* Prasad, *supra* note 72; *see also* Rivlin, *supra* note 62.

75. *See* Prasad, *supra* note 72; *see also* Rivlin, *supra* note 62. It is worth noting that Rivlin suggests that open source software firms have found a way to generate revenue by charging for the software support that accompanies dissemination of their open source code. *Id.*

76. *See supra* notes 62 and 72 and accompanying text.

77. *See* Benkler, *supra* note 4, at 276-77. Professor Benkler suggests that automobiles are similar examples of shareable goods because, once purchased, a vehicle has the capacity to transport a certain number of people despite its occupancy at any given moment. *See id.*

78. *See id.* at 277.

79. *See id.*

80. *See id.* at 290-300.

III. OPEN SOURCE AS AN ECONOMIC AND LEGAL MODALITY FOR RENEWABLE ENERGY TECHNOLOGY DISSEMINATION

A. A COMPARISON OF SOFTWARE WITH RENEWABLE ENERGY TECHNOLOGY

Renewable energy technology is intrinsically analogous to software in that academic research and development is the primary engine for innovation. Similar to software, renewable energy technology is a highly scientific and technical area in which academic expertise is highly valued. Further, the individuals conversant in the technical vernacular of renewable energy technology have a synergistic relationship that builds on individual contribution. Exchange of ideas relating to renewable energy technology is also already well-adapted to highly efficient modes of communication via internet portals and intranets. Contributors to the field of high technologies, such as software and renewable energy, value most the recognition they receive in the form of peer praise, Nobel prizes, and speaking engagements; monetary rewards are relatively less valuable.

As an example of the self-perpetuating cycle of collaborative renewable energy technology development, automobile technophiles and industry experts compete to develop the most unique and widely adaptable renewable energy vehicles. For instance, diesel engines have been adapted to run on used vegetable oil, concentrated wine, corn-made ethanol, and other derivatives of natural substances. Many of these projects began in garages with little promise for commercial viability, but through collaborative tinkering they eventually become viable alternative energy sources.

Economically, renewable energy technology fits squarely within the open source analytical paradigm. The industry is still fledgling and is stymied by enormous required initial capital investment that small private firms are unable to recoup under traditional market conditions. Supply-side markets for renewable energy preclude the proper competition that allows the cost of technology to subside. If renewable energy technology were converted into a highly tradable and non-unique commodity, just as software has become by way of open or pure competition, demand-side incentives would drive production and would facilitate entry by smaller firms who could justify their capital investment with newfound demand.[81]

Renewable energy technology is similar to software in that it is a shareable good that does not deplete with increasing use. Open source leads to increases in the "network effect" and decreases the switching cost among consumers.[82] Like software, renewable energy has manifold cross-applications, and when consum-

81. *See* Prasad, *supra* note 72.

82. *See* Schmidt & Schnitzer, *supra* note 72, at 486-92. The network effect describes the "complementary relationship between the adoption of a good by different customers" such that "additional adoption makes existing users better off . . . and increases the incentive to adopt." *Id.* at 486-87. The switching cost is the cost to a consumer of changing "platforms" that occurs by buying from different sellers. *Id.* at 490-92.

ers adopt a particular type of technology, lower transitional costs could lead to increasing network effects in consumer, commercial, and residential markets. Further, since demand-side incentives increase supplier competition and drive down prices, the cost to consumers to switch technologies decreases correspondingly. Renewable energy also provides the possibility to utilize excess capacity in a manner similar to software. For example, wind turbines continue to produce usable energy even after demand has subsided and there is an ebb. This excess energy can either be stored or transferred to alternate markets where capacity is insufficient to meet demand. Thus, just as excess computational capacity can be utilized in secondary markets, idle or under-producing renewable energy devices can be harnessed to serve alternate markets.

Therefore, renewable energy technology is inherently similar to software in a way that makes it adaptable to an open source modality for development and dissemination.

B. IMPLEMENTING OPEN SOURCE MODALITY FOR RENEWABLE ENERGY TECHNOLOGY: PROBLEMS AND POSSIBLE SOLUTIONS

1. Public Incentives

Thus far, this article has suggested that open source provides adequate incentives for development and innovation of competitive commodities such as software and renewable energy technology. Public subsidies or other government-sponsored incentives may, however, be necessary to stabilize and spur fledgling industries. Countries such as Germany, France, Italy, Norway, and the United States, as well as the European Commission and Taiwan, have already recognized this need and have begun supplying incentives to open source development.[83]

In order to spur renewable energy technology growth, governments should directly subsidize research, development, production, and adoption of open source technologies.[84] Already, the U.S. government funds a large percentage of private research and development.[85] Under the notion that basic research, open

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83. *See* Schmidt & Schnitzer, *supra* note 72, at 493. Thus far, it appears that most government intervention in connection with open source has focused on the software industry. Nevertheless, it is widely known that public subsidies also fund research and development into renewable energy technologies. *See, e.g.*, U.S. DEP'T OF ENERGY, ENERGY EFFICIENCY AND RENEWABLE ENERGY, FY 2006 BUDGET-IN-BRIEF (2005), *available at* http://www.eere.energy.gov/ba/pdfs/fy06_budget_brief.pdf.

84. Rae Kwon Chung, *The Role of Government in the Transfer of Environmentally Sound Technology*, *in* POSITIVE MEASURES FOR TECHNOLOGY TRANSFER UNDER THE CLIMATE CHANGE CONVENTION 47, 47-48 (Tim Forsyth ed., 1998); John A. Herrick, *Federal Project Financing Incentives for Green Industries: Renewable Energy and Beyond*, 43 NAT. RESOURCES J. 77 (2003). Government instruments to incentivize renewable energy development may include: renewable energy tax credits; federal ethanol incentives; private sector project finance participation; and promulgation of renewable portfolio standards. Herrick, *supra*, at 101-07.

85. *See* Schmidt & Schnitzer, *supra* note 72, at 494; *see also* Michael L. Katz & Janusz A. Ordover, *R&D Cooperation and Competition*, *in* BROOKINGS PAPERS OF ECONOMIC ACTIVITY: MICROECONOMICS 1990, at 137, 137-91 (Martin N. Baily & Clifford Winston eds., 1990).

source, and even renewable energy are public goods for which the free market supplies inadequate returns, the government has a corrective role to play. Further, non-monetary compensation has proven the most effective way to encourage individual contribution to those open source technologies that are researched and developed in universities or other public research labs.[86] Thus, the collaborative environment endemic to government-funded research labs will best facilitate public projects of the open source variety.[87]

2. Public Sector Adoption of Open Source Technologies

In addition to providing incentives for adopting an open source modality for renewable energy technology, governments should themselves adopt open source technologies because of their consumptive capacity. Many governments are using their public procurement and spending powers to adopt open source technologies and restrict government agencies from using proprietary technology platforms.[88] Governments may force universities and government agencies to use open source products as alternatives to proprietary ones under the notion that open source products are qualitatively more reliable, efficient, adaptable, quicker to improve, and cost considerably less overall. For example, Brazil has become the first country to require any government-subsidized company or research institute in the software development business to develop and license open source software so that the public may share in the resource it has funded.[89] President da Silva of Brazil appears poised to deploy open source computer technology to the masses by unveiling an open source project called "PC Conectado."[90] State encouragement of open source is even more apt in the energy sector because governments are some of the largest consumers of energy and therefore wield substantial influence over the energy industry.[91] Just as governments like Brazil's are using their leverage over subsidization and spending powers in academia to require an open source modality, governments could also leverage their spending powers and widespread subsidization in the energy industry to require development, adoption, and licensing of open source energy projects.

3. Legal Licensing

Although the law has been slow to adapt to technological innovations, and

86. *See* Kahan, *supra* note 63, at 93-97.
87. *See id.* at 93-97.
88. *See* Schmidt & Schnitzer, *supra* note 72, at 496; Hal Burman & Don Wallace, Jr., *New Frontiers for Private Law: Public Procurement, Infrastructure Projects*, 34 INT'L L. NEWS 1 (2005); Todd Benson, *Brazil: Free Software's Biggest and Best Friend*, N.Y. TIMES, Mar. 29, 2005, at C1.
89. *See* Benson, *supra* note 88.
90. *Id.*
91. *See* Herrick, *supra* note 84, at 107. In the United States, the federal government uses roughly 1.01 quads (quadrillion BTU) of power for its operations, which amounted to US$7 billion in fiscal year 2000. *Id.*

many fear that the law does not recognize open source, these new licensing schemes do not create significantly novel or complicated legal issues because they already exist within the traditional realm of licensing law. Open source developers are more than idealistic individuals seeking to circumscribe the capital prowess of proprietary mega-developers. Open source licenses operate squarely within the context of the legal copyright structure to restrict the proprietization of source code.[92] Open source licenses, such as those offered by GPL, Apache Software, the Free Software Foundation, the Public Patent Foundation, and the Electronic Frontier Foundation, utilize binding contractual covenants to maintain open source code in the public arena.[93] Litigation arising from open source licenses has been sparse in the United States; however, it is noteworthy that the anti-trust settlement between the Attorney General and the Microsoft Corporation initially required Microsoft to release its "Internet Explorer" platform via open source.[94] One could explain the apparent lack of litigation of disputes arising under open source licenses by positing that individuals who partake in the open source movement and develop software in the public domain are relatively self-selecting. That is, open source developers write source code to contribute towards the "public good" and maintain a strong belief that software code ought to remain in the public domain.[95] Assuming that open source developers are those least likely to proprietize source code for individual profit, developers might freely enter into the open source license merely to memorialize a pre-established agreement founded on trust, collaboration, and reciprocity.[96]

At the inter-governmental level, there is robust legal authority for states to compulsorily license technology and otherwise copyrighted information in order to promote access to and transfer of environmentally-sound energy technologies.[97] The World Trade Organization (WTO) has explicitly recognized in the

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92. *See supra* notes 57-61 and accompanying text.

93. *See* GNU General Public License (June 1991), http://www.gnu.org/licenses/gpl.txt; Apache License (Jan. 2004), http://www.apache.org/licenses/LICENSE-2.0.txt. Open source licenses create binding contractual rights and obligations similar to proprietary software licenses. *Id.*; *see also supra* notes 58-59 and accompanying text.

94. *See* Massachusetts v. Microsoft Corp., 373 F.3d 1199, 1227-31 (D.C. Cir. 2004). Ultimately, the D.C. Circuit overturned a district court decision upholding the settlement agreement's requirement that Microsoft license its Internet Explorer through open source. *Id.* Nevertheless, it is significant that at least one court upheld the validity of a settlement proposal to require a proprietary software developer to freely license one of its coveted software platforms through open source.

95. *See* Kahan, *supra* note 63, at 93-97.

96. *See id.* at 93-94.

97. *See* World Trade Organization, *Declaration on the TRIPS Agreement and Public Health*, ¶¶ 5-6, WT/MIN(01)/DEC/2 (Nov. 14, 2001) [hereinafter Declaration on TRIPS] (supporting states' rights to compulsorily license products in furtherance of public interest); *see also Agenda 21*, *supra* note 30, ch. 34.18; Markus Nolff, *Paragraph 6 of the Declaration on the TRIPS Agreement and Public Health and the Decision of the WTO Regarding Its Implementation: An "Expedition Solution"?*, 86 J. PAT. & TRADEMARK OFF. SOC'Y 291 (2004); Thomas A. Haag, *TRIPS Since DOHA: How Far Will the WTO Go Toward Modifying the Terms for Compulsory Licensing?*, 84 J. PAT. & TRADEMARK OFF. SOC'Y 945, 949-53 (2002).

public health context the right of states to compulsory license technology as a way to promote access to technology that prevails in proprietary states.[98] States' authority to compulsory license technology that travels in the flow of international trade is predicated on the notion that legally enforceable intellectual property rights may at times interfere with a state's ability to protect its public welfare and to regulate multinational foreign direct investment.[99] For example, developing countries may compulsorily license proprietary renewable energy software owned by a multinational corporation to enable local firms to develop the know-how to develop and deploy energy technology to meet burgeoning demand. Despite the availability of the compulsory license, these local firms should then comply with the spirit of open source by preserving the software and hardware "source code" in the public domain so as not to undermine the multinational firm's intellectual property rights or to gain undue profits. Because the WTO recognizes the right of states to compulsory license technology that is otherwise protected by intellectual property rights to promote public health in the flow of international trade, the state's conduct would likely not be subject to WTO sanctions as unfair trade activity.[100]

In addition to being widely recognized as a legitimate tool, compulsory licensing has many legal and economic advantages. Use of a state's compulsory licensing authority in the context of renewable energy technology lowers the legal and economic barriers that market-based technology enjoys on account of intellectual property rights. Further, compulsory licensing authority is a legal mechanism that governments may employ in taking steps to promote access to renewable energy technology. Thus, states should prevent traditional intellectual property rights from interfering with their obligations under international environmental technology transfer treaties by exercising inherent economic rights to compulsorily license related technology within the international trade regime pursuant to the Trade Related Aspects of Intellectual Property Rights Agreement (TRIPS).[101]

To wit, open source licenses must be enforceable and create binding obligations under law in order to be viewed as legitimate. Judicial enforcement of the binding effect of open source licenses and affirmation of the legislature's authority to compulsorily license open source renewable energy technology

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98. *See* Declaration on TRIPS, *supra* note 97, ¶¶ 5-6.

99. *See* Declaration on TRIPS, *supra* note 97 and accompanying text; *Agenda 21*, *supra* note 30 and accompanying text; U.N. Comm'n on Sustainable Dev., *The Role of Publicly Funded Research and Publicly Owned Technologies in the Transfer and Diffusion of Environmentally Sound Technologies*, ¶ 106(a), Background Paper No. 22 (1998), http://www.un.org/documents/ecosoc/cn17/1998/background/ecn171998-bp22.htm (last visited Nov. 12, 2005).

100. *Cf. supra* note 97 and accompanying text.

101. *See* Declaration on TRIPS, *supra* note 97, ¶¶ 5-6; *supra* note 33 and accompanying text; *see also* Marrakesh Agreement Establishing the World Trade Organization, Apr. 15, 1994, Agreement on Trade-Related Aspects of Intellectual Property Rights, Annex 1C, 108 Stat. 4809, 1867 U.N.T.S. 14, 33 I.L.M. 1140 (1994).

depends in part on the extent of a government's obligation under international law to promote the international transfer of renewable energy. Open source methodologies, manifested in the renewable energy software and technology industries, will only be legally recognized if legislatures and judicial bodies enforce open source instrumentality as binding. The multilateral renewable energy technology framework must be said to create binding international legal obligations on governments in order to hold states accountable for their effort to promote the transfer and dissemination of renewable energy.

Although the Rio Declaration and Agenda 21, which both arose from the 1992 Rio Conference, are essentially aspirational declarations of a global policy consensus, the UNFCCC creates binding obligations on the part of governments to affirmatively promote renewable energy technology.[102] Article 4 of the UNFCCC speaks with obligatory language in a way that appears to evince the drafters' intent to create binding obligations on governments.[103] Article 4 uses phrases such as "shall . . . promote and cooperate" and "shall take all practicable steps to promote, facilitate and finance" to articulate the Framers' intent to obligate governments to affirmatively undertake renewable energy technology transfer initiatives.[104]

When the UNFCCC is viewed in light of the Rio Declaration and Agenda 21, it is evident that the member states intended the UNFCCC to create *legal* obligations as opposed to expressing a philosophical or political understanding.[105] The existence of the Rio Declaration and Agenda 21, as political expressions of a global environmental and technological consensus, and the UNFCCC as a legal instrument creates a coherent legal and political paradigm designed to guide member states and to hold them accountable for derogation from their treaty obligations. While the UNFCCC's language may be said to create legal obligations on the part of member states, it appears to stop short of evincing an intent to be immediately "self-executing."[106] The language of the UNFCCC suggests that Article 4 was not intended to be self-executing because such terms as "shall . . . promote and cooperate" and "shall take all practicable steps" connote progressive implementation of the treaty's obligations.[107] A government is ordinarily said to

102. *See supra* notes 22-28 and accompanying text; *see also* Gaetan Verhoosel, *Beyond the Unsustainable Rhetoric of Sustainable Development: Transferring Environmentally Sound Technologies*, 11 GEO. INT'L ENVTL. L. REV. 49, 58-65 (1998); *Agenda 21*, *supra* note 30, ch. 34.18.

103. *See supra* notes 22-24 and accompanying text.

104. *See* UNFCCC, *supra* note 11, arts. 4.1(c), 4.5.

105. *See supra* note 46 and accompanying text; *see also* Verhoosel, *supra* note 102, at 58-62.

106. The "self-executing treaty" doctrine refers to whether a treaty creates a de facto rule of decision for a state's judicial branch. *See* Foster & Elam v. Neilson, 27 U.S. 253, 314 (1829). Domestic law is often the source of a state's internal definition of what constitutes a "self-executing" treaty. *Id.* Where a treaty is said to not be "self-executing" a state's legislature must affirmatively pass enabling legislation that makes the relevant treaty a judicial rule of law. *Id.* Otherwise, a "self-executing" treaty becomes a de facto judicial law without further legislative action. *Id.*

107. *See* UNFCCC, *supra* note 11, arts. 4.1(c), 4.5; *supra* notes 22-24 and accompanying text.

"take steps" when it passes domestic legislation or promulgates administrative regulations, and such steps must only be "practicable" and "appropriate" under Article 4 of the UNFCCC.[108]

The UNFCCC does not appear to create burdensome or costly obligations on member states, but provides that they shall affirmatively promote the transfer of renewable energy technologies. Government support for open source renewable energy software and hardware technology is entirely consistent with the spirit of the UNFCCC and the elucidating policy declarations with which it was accompanied.[109] Further, performance under the UNFCCC appears to be bilateral and conditional on mutual cooperation.[110] The Treaty requires proportional compliance by developed and developing countries because effective implementation of treaty obligations by developing countries depends on the performance by developed countries of their responsibility to provide financial resources and technology transfer.[111] Therefore, the law currently recognizes binding legal obligations from developed and developing countries alike to collaborate towards renewable energy technology development.

IV. NOW IS THE TIME TO IMPLEMENT AN OPEN SOURCE PARADIGM FOR RENEWABLE ENERGY TECHNOLOGY DISSEMINATION

Open source has evolved as a paradigm of technological production and expanded beyond the ambit of software to a point where it is ready to be applied successfully to renewable energy technology. Advancing proprietary systems of renewable energy technology will only deepen the isolation of developing countries and widen the inequity in access to such technology between the developed and the developing world. While technology development is still incipient in developing countries, now is the time to implement an open source movement to set these countries on the right track. The frontier of open source projects represents new opportunities for public subsidization because they are ripe for development and deployment. In the field of renewable energy, materials science is on the verge of technological and scientific breakthroughs in silicon-based semiconductors, which form the foundation for microprocessors and photovoltaic devices.[112] Moreover, advancements in semiconductor technology

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108. *See* UNFCCC, *supra* note 11, art. 4.5.

109. *See Agenda 21*, *supra* note 30, ch. 34.18.

110. *See* UNFCCC, *supra* note 11, art. 4.7; Verhoosel, *supra* note 102, at 58-62.

111. *See* UNFCCC, *supra* note 11, art. 4.7; Verhoosel, *supra* note 102, at 58-62.

112. *See* Brian McConnell, *Renewable Energy - The Next Opportunity for Silicon Valley*, O'REILLY NETWORK, Dec. 10, 2004, http://www.oreillynet.com/pub/a/network/2004/12/10/energy.html. The recent fortieth anniversary of Moore's law has brought renewed attention to the progress of technological innovation for silicon-based chips. *See Moore's Law on Chips Marks 40th*, BBC NEWS, Apr. 18, 2005, http://news.bbc.co.uk/1/hi/technology/4446285.stm. Other examples of open source technology projects include a "super efficient battery charger and reenergizer," which is a variant of the Bedini SG. *See* Pure Energy Systems, M Charley's "SEBCAR", http://peswiki.com/index.php/Directory:SEBCAR (last visited Dec. 15, 2005). This battery

promote the cross-application or "network effect" of the materials science between computing and renewable energy technology.[113] Developments in the information technology industry to make software and computer technology more user-friendly can be used to facilitate installation and use of renewable energy technologies, which otherwise may seem cumbersome and overly technical to operate.[114] The same human capital that has financed and developed open source software would readily and ably apply its expertise to the applied science of developing marketable renewable energy technologies.[115] Open source technology operations are ripe for public sector adoption because the technology is extremely low-cost, highly refined, functional, and buttressed by a capable information technology sector.[116] Open source renewable energy hardware projects are currently being undertaken in limited capacities, and the technicians and researchers are collaborating through information sharing networks to disseminate their research and contribute to the public database, of knowledge.[117]

In addition to breakthroughs in mechanical technology, renewable energy software is ripe for development and deployment. In the realm of renewable energy-related software, a myriad of applications are currently available in primarily proprietary format to analyze, database, and simulate energy efficiency.[118] Software platforms that have applicability to renewable energy technologies are directly susceptible to aforementioned open source incentives.[119] Because renewable energy technology itself is constantly changing to meet industry demands, software applications must be continually updated and improved to reflect changing benchmarks of efficiency, different hardware applications, and different hardware contexts. Thus, open source methodologies, which

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operates by extracting more energy than it uses. Pure Energy Systems has several inactive projects, including: "Bowman Magnetic Motor," "Ion Source Beam Projector," "Ed Gray Motor Variant by Gary Magratten," "Charly [sic] Brown's Thermal Electric Chip," and a "Stirling Engine." *See* Pure Energy Systems, Open Sourcing Projects, http://www.pureenergysystems.com/os/index.html (last visited Nov. 12, 2005). These projects demonstrate that open sourcing can propel research and development to the cutting edge. Additionally, open source practices are now being applied in the biotechnology field by developing techniques to create genetically modified crops without infringing on the patents of mega-biotechnology firms. *See* Andrew Pollack, *Open-Source Practices for Biotechnology*, N.Y. TIMES, Feb. 10, 2005, at C8. The researchers who have published their findings in *Nature* will release the genetic modification technique into the public forum for open use and innovation. *Id.* These researchers succeeded in modifying three types of bacteria to be used as hosts for desirable genes that could be inserted into three plants: rice, tobacco, and Arabidopsis. *Id.* The open source initiative is called the Biological Innovation for Open Society, or BIOS. *Id.*

113. *See* McConnell, *supra* note 112; *supra* note 82 and accompanying text.

114. *See* McConnell, *supra* note 112.

115. *See id.*; *see also supra* notes 64-71 and accompanying text.

116. *See* Rivlin, *supra* note 62 and accompanying text.

117. *See, e.g.*, Free Energy News, http://freeenergynews.com (last visited Sep. 24, 2005).

118. *See, e.g.*, U.S. Dep't of Energy, Energy Efficiency and Renewable Energy, Building Energy Software Tools Directory, http://www.eere.energy.gov/buildings/tools_directory (last visited Sept. 24, 2005); Natural Resources Canada, RETScreen International, Software & Data, http://www.retscreen.net/ang/d_o_view.php (last visisted Nov. 9, 2005) [hereinafter RETScreen International].

119. *See generally* Kahan, *supra* note 63; *supra* notes 64-71 and accompanying text.

motivate individuals to provide ad hoc improvement, provide the necessary incentives to innovate software that accompanies renewable energy technologies.[120] Further, innovative renewable energy platform software may decrease the cost of deploying the actual technology because sophisticated simulation modeling could reduce the cost of testing, siting, and operating the renewable energy technology.

Beyond the software that complements renewable energy technology, collaborative research and data sharing can take place through electronic portals and databases for ongoing and completed research.[121] Open source developers frequently share their research to build a public database of knowledge to support open source software initiatives and the accompanying hardware applications. Electronic databases and bulletin boards are widely used by university researchers, private researchers, and public sector researchers.[122] Therefore, renewable energy mechanical technology and renewable energy software applications are ripe for adaptation to an open source modality.

V. CONCLUSION

The spate of recent media reports addressing rising energy costs in the developed world reveal a deep divide between the progress of energy technology being innovated and deployed under proprietary legal regimes and environmental degradation and human suffering. Developing countries as well as consumers in the developed world are struggling to achieve autonomy and to define the fates of their energy infrastructures, while multinational behemoths possess the technological key to their progress. The international community has convened with regularity to address how technology can be utilized to ameliorate human suffering, geopolitical energy disputes, and environmental degradation. The product of these conferences has been an emerging global framework that values sharing, reciprocity, and collective action over unbridled intellectual property rights. Meanwhile, developed countries seek to expand these intellectual property right protections in regions where such rights interfere with the ability to meaningfully deploy technology that could facilitate environmentally-friendly development.

The open source software movement is coming of age and expanding into industries beyond its roots in the software field. Valuable innovations in the biotechnology, applied software, mechanics, and mechanical energy technology fields have been developed under the open source methodology. Within the international environmental treaty framework, states have obligations to promote the transfer and dissemination of renewable and environmentally-friendly tech-

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120. *See supra* notes 64-71 and accompanying text.
121. *See* RETScreen International, *supra* note 118.
122. *See supra* notes 64-71 and accompanying text.

nology. Governments should employ the panoply of legal and economic tools available under and sanctioned by international law to meet consensual multilateral obligations. Open source technology initiatives should be nurtured by public incentives, public sector procurement projects, and legal alternatives to traditional conceptions of intellectual property rights.

Legally indoctrinated preferences for unbridled intellectual property rights protection have created uneconomic and non-competitive barriers to entry and legal inequality, thereby preventing the widespread development, deployment, adoption, and transfer of renewable and environmentally-friendly technology. As international law progresses to re-define states' obligations vis-à-vis technology transfer and the global environment, states must update their incentive mechanisms to nurture frontier technological movements. A global consensus obligates governments to use both economic and legal means to reduce the widening deficit between technological progress and environmental and human destruction.